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Refresher course: Radiosurgery/Intracranial FSRT

Fundamentals physical, biological and clinical radiosurgery

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Stereotactic Radiosurgery (SRS) is a non-invasive technique for the delivery of highly focused ionizing radiation with extreme accuracy. It is used in neurosurgical practice as a less invasive means of targeting benign and malignant brain tumors.

Its ability to elicit a desired response (e.g. tumor cell death) with minimal effect on normal surrounding structures is one of the many benefits that have led to more widespread use of stereotactic radiosurgical procedures in recent years under the guidance of a multidisciplinary team comprised of a neurosurgeon, radiation oncologist and medical physicist. To achieve the desired outcome, the SRS procedure can be performed in either a single treatment or in several applications (hypofractionated or conventional fractionated). Stereotactic radiosurgery is most often an outpatient procedure.

Novel imaging techniques have been developed to optimize and expand the uses of the stereotactic radiosurgery. Computer tomography (CT) and magnetic resonance imaging (MRI) techniques have improved the quality of the brain image and achieved a more precise localization of tumors in the brain. Combining these innovative imaging technologies with high-speed workstations that rapidly calculate and display 3-D dose distributions enables more effective and productive uses of these technologies. In addition, positron emission tomography (PET) scans provide images that include metabolic data and functional data and in doing so add another layer of sophistication in the treatment of more complex targets such as rapidly proliferating tumors, including gliomas and metastases.

Radiosurgery is an especially attractive therapeutic option for brain metastases (the most common adult brain tumor) because it can be used to treat small lesions that would be otherwise inaccessible with invasive surgery due to sensitive adjacent critical structures. Stereotactic radiosurgery is currently being used to treat newly diagnosed metastatic tumors, recurrent brain metastases after previous whole brain radiation therapy (WBRT), and as a "boost" after WBRT. Metastatic brain tumors have high incidence and follow a rapidly progressive course, requiring complex management which includes a combination of surgery, radiation and radiosurgery.

Solitary metastases are especially good targets for radiosurgical treatment when they are caught in earlier stages by MRI surveillance at less than 3.5 cm, because they are usually spherical, discrete and contrast enhancing, allowing for accurate lesion delineation. In addition, most metastases are uniformly sensitive to single fraction radiotherapy.

For multiple brain metastases, treatment becomes less effective as the number of tumors increases. A study demonstrated that the probability of tumor control after surgery and WBRT or radiosurgery decreases from 64% for one intracranial metastasis, to 51% for two tumors, and to 41% for three. Patients with fewer than four small- or medium-sized tumors can respond favorably to stereotactic radiosurgery. Hypofractionated radiosurgery is the preferred option for patients that are poor surgical candidates due to co-morbidities or advanced systemic disease and it can be combined with resection for treatment of larger tumors. FSRT can particularly be beneficial for patients with large lesions or lesions located near critical structures.

In general, algorithms are followed to treat brain metastases through multimodal techniques that combine resection, WBRT and radiosurgery in attempt to maximize survival rates.

SRS was also used in the management of gliomas. Gliomas have astrocytic, oligodendroglial, ependymal and mixed subtypes. Low grade gliomas (LGG) are curable by means of current multimodal treatment techniques, the main goal in

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high grade gliomas (HGG) is the prolongation of survival with a high quality of life as much as possible. Currently, there are many ongoing clinical studies focused on the role of SRS in the management of gliomas. In most cases, the treatment protocols should be individualized. SRS seems a valuable treatment option for local control of recurrent or residual ependymomas. Although the guideline indications of SRS in the management of gliomas are not definite yet, favorable results are being reported especially for pilocytic astrocytoma and ependymoma. SRS also makes significant contributions to multimodal treatment modality of GBM as an adjuvant, as well. SRS might safely be used for carefully selected patients with low complication rates and high efficacy. Many prudential studies are also conducted in this growing field of neurosurgery.

It presents an especially attractive alternative option to invasive surgery for patients with co-morbidities. Radiosurgery continues to be constantly evaluated for its benefits, risks, and effectiveness in comparison to standard surgical, radiation and pharmacological options.